LED Application Series:

Recessed Downlights

Recessed downlights are very common in both residential and commercial buildings. Is this a good application for LEDs? This fact sheet explores issues unique to this type of luminaire, and the potential for use of LEDs in downlights.


Source: PNNL

Recessed downlights are the most common installed luminaire type in residential new construction. Downlights are used for general ambient lighting in kitchens, hallways, bathrooms, and other areas of the home. Downlights with small apertures and more directional lensing and baffling are also used for wall-washing and accent lighting. In commercial settings, a wide variety of downlight types, sizes, and finishes are used in lobbies, perimeter areas, hallways, and restrooms.

The light output of a recessed downlight is a function of the lumens produced by the lamp and the luminaire efficiency. Reflector-style lamps are specially shaped and coated to emit light in a defined cone, while "A" style incandescent lamps and CFLs emit light in all directions, leading to significant light loss within the luminaire. Downlights using non-reflector lamps are typically only 50% efficient, meaning about half the light produced by the lamp is wasted inside the fixture. LEDs are more directional, but can they provide enough light? For comparison, the table below shows typical light output and efficiency of residential-style fluorescent and incandescent recessed downlights and an LED downlight.

Examples of Recessed Downlight Performance Using Different Light Sources

		Fluorescent*		Incandescent*		LED**
		26W pin-based CFL	15W R-30 CFL Edison base	65W R-30	100W A-19	LED 15W Downlight
LAMP	Rated lamp lumens	1800	750	755	1700	unknown
	Lamp wattage (nominal W)	26	15	65	100	9 × 1W LEDs
	Lamp efficacy (lm/W)	**70**	**50**	**12**	**17**	**45**
LUMINAIRE	Luminaire efficiency	50%	90%	90%	50%	unknown
	Delivered light output (lumens), initial	900	675	680	850	300
	Luminaire wattage (nominal W)	27	15	65	100	15
	Luminaire efficacy (lm/W)	**33**	**45**	**10**	**9**	**20**

*Based on photometric data for commonly available products. Actual product performance depends on reflectors, trims, lamp positioning, and other factors. Assumptions available from PNNL.
**Based on one commercially-available product tested. Other LED-based downlights may differ. Lamp efficacy for the LED product refers to the manufacturer listed "typical luminous flux" of the LEDs used. Luminous flux of the 9-LED array is not known.

Even though the 26W CFL is the most efficacious light source listed, the 15W reflector CFL provides higher luminaire efficacy, i.e., total lumens out of the fixture per watt consumed. The 15W LED downlight provides less than half the delivered light output of the 15W reflector CFL. As LED technology matures, this performance is expected to improve.

Terms

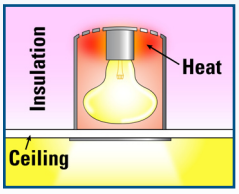
Luminaire – a complete lighting unit including lamp(s), ballast(s) (when applicable), and the parts designed to distribute the light, position and protect the lamps, and connect to the power supply.

Luminaire (fixture) efficiency – the ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein; expressed as a percentage.

Luminaire efficacy – total lumens provided by the luminaire divided by the total wattage drawn by the fixture, expressed in lumens per watt (lm/W).

ICAT – stands for "insulated ceiling (or "insulation contact"), air tight" and refers to ratings on recessed downlight luminaires used in residential construction.

Downlights installed on the top floor of a house are immersed in insulation, creating a high-temperature operating environment that is difficult for CFLs and potentially similarly challenging for LEDs. Further, energy codes in most states require downlights installed in the building shell to be rated "air tight" to minimize loss of heating and cooling energy.



Potential for use of LEDs in downlights

Given the prevalence of downlights in both residential and commercial buildings, potential energy savings from high-performing, energy-efficient downlights would be significant. The high-temperature environment described above has plagued attempts to use CFLs in downlights, although recent developments in reflector CFLs are promising (see **www.pnl.gov/rlamps**). Would LEDs do better?

The inherent directionality of LEDs is a potential advantage for their use in downlighting applications. If designed effectively, LED downlights could essentially eliminate luminaire light losses. LEDs also work with standard wall-mounted dimmers, unlike CFLs.

However, to approach the light output typically expected for downlights requires multiple LEDs to be grouped together. Clustering LEDs in the relatively small downlight package generates considerable heat. Actual light output depends on good thermal management in the fixture. If the heat is not adequately managed, LED device temperature will rise, light output will fall, and the useful life of the fixture will be disappointingly short. This concern is particularly important in residential insulated ceiling applications.

LED downlights available to date provide about half the delivered light output of downlights using 65W R incandescent or 15W reflector CFLs. However, as LED technology and product designs mature, LEDs are expected to compete favorably with traditional light sources in downlighting applications.

Comparison of Recessed Downlight Lamping Options

	Advantages	Disadvantages
Incandescent Reflector	• Dimmable • High color quality • Low lamp cost	• High wattage • Short life (2000 hrs) • Heat increases cooling load
CFL Reflector	• High efficacy • Long life (6000-8000 hrs)	• Few dimmable products • More expensive than incand.
CFL Pin-based	• High efficacy • Long life (10000 hrs)	• Few dimmable products • More expensive than incand. • Replacement lamps can be difficult to find
LED Downlight	• Dimmable • Potentially long life • Lower wattage than incand. • Directional light source	• Relatively low light output* • Expensive to purchase* • Very sensitive to high-temperature environment* • Replacement lamps not available

*Listed disadvantages reflect current status of LED technology (Nov 2006). Expected technology improvements in coming years will mitigate and possibly eliminate these disadvantages.

In conclusion, recessed downlighting is potentially a good application for LEDs, when the technology matures. As new LED downlights are introduced on the market, they should be evaluated carefully, keeping the following considerations in mind:

- The light output of current LED downlights may be 25% to 50% lower than standard incandescent and CFL downlights. The overall room lighting design will need to account for this.
- Ask the LED downlight manufacturer about measured performance of the luminaire in insulated ceilings. Does the luminaire design adequately manage the heat? If such performance information is not available, it may be best to avoid LED use in insulated ceiling, airtight (ICAT) conditions.

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PNNL-SA-52145
November 2006